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# **A CYCLE TIMER FOR TESTING ELECTRIC VEHICLES**

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Work performed for

**U.S. DEPARTMENT OF ENERGY**  
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**Division of Transportation Energy Conservation**

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FOR TESTING  
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Division of Transportation Energy Conservation  
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A CYCLE TIMER FOR TESTING  
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ABSTRACT

A cycle timer was developed to assist the driver of an electric vehicle in more accurately following and repeating SAE driving schedules. These schedules require operating an electric vehicle in a selected stop-and-go driving cycle and repeating this pattern until the vehicle ceases to meet the requirements of the cycle. The heart of the system is a programmable read-only memory (PROM) that has the required test profiles permanently recorded on plug-in cards, one card for each different driving schedule. The PROM generates a direct-current analog signal that drives a speedometer displayed on one scale of a dual-movement meter. The second scale of the dual-movement meter displays the actual speed of the vehicle as recorded by the fifth wheel. The vehicle operator controls vehicle speed to match the desired profile speed. One second before a speed transition (such as acceleration to cruise or cruise to coast), a small buzzer sounds for 1/2 second to forewarn the operator of a change. A longer signal of 1 second is used to emphasize the start of a new cycle. The PROM controls the recycle start time as well as the buzzer activation. The cycle programmer is powered by the test vehicle's 12-volt accessory battery, through a 5-volt regulator and a 12-volt dc-to-dc converter.

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The Lewis Research Center, as part of an interagency agreement with the Energy Research and Development Administration (ERDA), was requested to develop a characterization of the state of the art of electric and hybrid vehicles. As part of this study, Lewis Research Center personnel directed the testing of 14 electric and hybrid vehicles during 1976 and 1977 to evaluate vehicle performance under various operating conditions. The vehicle tests were conducted at test tracks in accordance with the Energy Research and Development Administration Electric and Hybrid Vehicle Test and Evaluation Procedure (ERDA-EHV-TEP). Most of the performance tests in this procedure are those contained in the Society of Automotive Engineers Electric Vehicle Test Procedure, SAE J227a (Feb. 1976). The tests include measurements of range at constant speed, range when operating over prescribed driving schedules, acceleration, maximum speed, gradeability, and braking. The driving schedules of interest for this evaluation were schedule B, characterized by a cruise speed of 32 km/hr (20 mph), schedule C, characterized by a cruise speed of 48 km/hr (30 mph), and schedule D, characterized by a cruise speed of 72 km/hr (45 mph).

A typical cycle of a given schedule includes an acceleration phase, a cruise period, a short coastdown, and a braking phase followed by an idle period. For example, figure 1 illustrates the timing requirements of the schedule B test cycle. The various times are identified by the subscripts. For the acceleration phase  $t_a$ , the vehicle is required to be accelerated from zero to 32 km/hr in  $19 \pm 1$  seconds; for the cruise period  $t_{cr}$ , the speed of the vehicle must be held constant at 32 km/hr for  $19 \pm 1$  seconds. After cruising, the vehicle is allowed to coast for  $4 \pm 1$  seconds and is then braked to a complete stop in  $5 \pm 1$  seconds. The cycle is completed by an idle time  $t_i$  of  $25 \pm 2$  seconds. After the idle period, the next cycle is begun. This schedule is repeated until the vehicle ceases to meet the requirements of the prescribed cycle. The shaded bands on the figure indicate that the velocity profiles are

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somewhat tolerant but that the time bases are to be held within their specified limits. The required times for schedules B, C, and D are given in table I.

When a test driver tried to operate the vehicle over any of the prescribed driving schedules, he found it very difficult to simultaneously direct the vehicle, watch the speedometer, and monitor a stopwatch. Thus, one man alone could not operate the vehicle on these driving schedules. A second person was required to act as a "navigator" for the driver. The navigator read a stopwatch and called the various times to the driver. The driver then adjusted the speed according to the times being called out by the navigator. This procedure was tedious and resulted in mistakes being made, especially in the latter stages of the tests.

The test vehicle cycle timer was developed to allow the driver to follow the prescribed test schedule. It obviated the need for a passenger in the vehicle to assist the driver. It also improved the accuracy and repeatability of the test results.

The cycle timer was designed to provide the driver with a "heads-up" visual means of easily following an entire test cycle, whether it be SAE J227a or any other desirable test profile. The package that evolved was essentially a two-part package: an electronics section, shown on the left in figure 2; and a dual-movement meter, shown on the right. All the system electronics are contained in four plug-in cards that can be easily removed, replaced, or repaired.

The cycle timer was built as two separate modules because of the physical limitation of available space on the dashboard of most vehicles. The typical arrangement of the cycle time is shown in figure 3. The meter is situated directly in front of the driver and the electronic box is set on the side within easy reach of the driver. The heart of the system is a programmable read-only memory (PROM) that has the required test profile for schedule B, C, or D permanently recorded on it. The PROM is mounted on one of the four plug-in cards.

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Each SAE J227a driving schedule requires a separate PROM. Changing to a different driving schedule is easily accomplished within a few minutes by merely changing PROM cards.

A block diagram of the entire cycle timer is shown in figure 4. A clock oscillator with a timing resolution of 1/2 second drives a timing counter that addresses the profile memory. The PROM generates a direct-current analog signal that controls the movement of one needle along the scale of the dual-movement meter. This needle then automatically moves through the desired test cycle. The second needle of the meter is driven by an analog signal produced from the fifth wheel. This signal displays the actual speed of the vehicle. The operator of the vehicle controls vehicle speed to achieve the desired test profile by "matching" needles. The accuracy of the displayed speed generated by the test vehicle cycle timer is better than 1.6 km/hr (1.0 mph), which is within the accuracy requirements of the test procedure.

One second before each speed transition, such as from acceleration to constant-speed cruise or from constant-speed cruise to coastdown, a small buzzer sounds for 1/2 second to forewarn the operator of an impending change. A longer signal of approximately 1 second is used after the idle period to emphasize the start of a new cycle. The PROM controls the recycle start time as well as the buzzer activation.

Three switches are incorporated into the test vehicle cycle timer (shown in fig. 5). The first switch on the left is used in case of a false start or error in the middle of a test run. It automatically resets the timer and meter back to the start of a new cycle. The switch on the right activates a digital display that stores the total number of cycles completed. The middle switch resets the stored number of cycles that have been completed back to zero.

Features of the cycle timer include minimal current drain and protection against overvoltage and against the accidental reversal of supply voltage. It was designed to be powered from a 12-volt

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source. In some tests, the 12-volt accessory battery of the vehicle was used; in other tests, a dedicated 12-volt instrument battery was incorporated. The components used in the timer are standard "off the shelf" items that are readily available. The 12-volt battery voltage is reduced by a 5-volt regulator to provide logic power. A 12-volt dc-dc converter is used to provide analog and memory power. The weight of the cycle timer is less than 4 pounds.

The need for the cycle timer became apparent early in the vehicle test program. After it was built and tested, it was successfully used on eight of the 14 test vehicles. The Lewis Research Center has published a Technical Brief, LEW-12977, containing the detailed circuit diagrams and other information needed to fabricate a cycle timer. For more information, call or write

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TABLE I. - TEST SCHEDULE FOR REPEATABLE DRIVING  
PATTERN SAE J227a

| Cycle phases        | Driving schedule                  |               |               |
|---------------------|-----------------------------------|---------------|---------------|
|                     | B                                 | C             | D             |
|                     | Vehicle cruise speed, km/hr (mph) |               |               |
|                     | 32±1.5 (20±1)                     | 48±1.5 (30±1) | 72±1.5 (45±1) |
|                     | Time in cycle phase, sec          |               |               |
| Acceleration, $t_a$ | 19±1                              | 18±2          | 28±2          |
| Cruise, $t_{cr}$    | 19±1                              | 20±1          | 50±2          |
| Coastdown, $t_{co}$ | 4±1                               | 8±1           | 10±1          |
| Braking, $t_b$      | 5±1                               | 9±1           | 9±1           |
| Idle, $t_i$         | 25±2                              | 25±2          | 25±2          |
| Total               | 72±3                              | 80±3          | 122±4         |

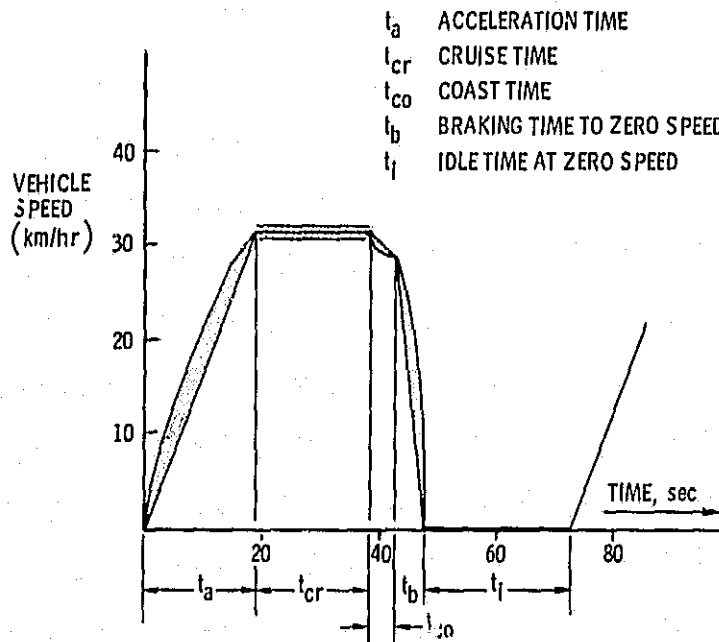


Figure 1. - Schedule "B" test cycle, SAE J227a.

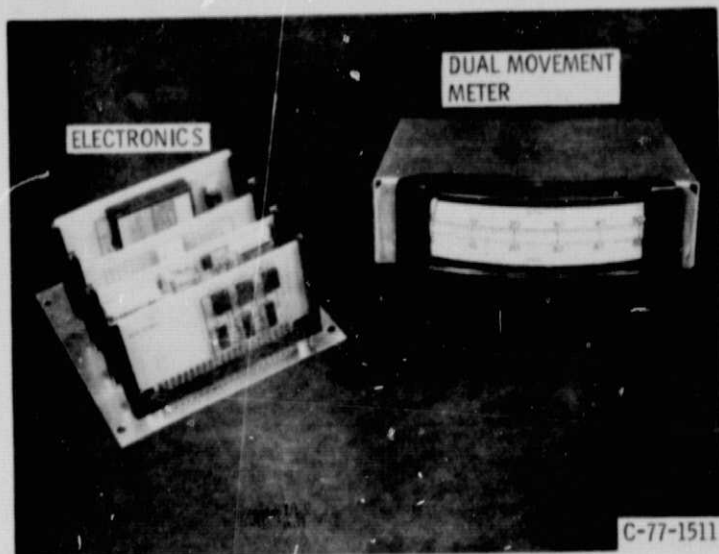


Figure 2. - Two main parts of cycle timer.

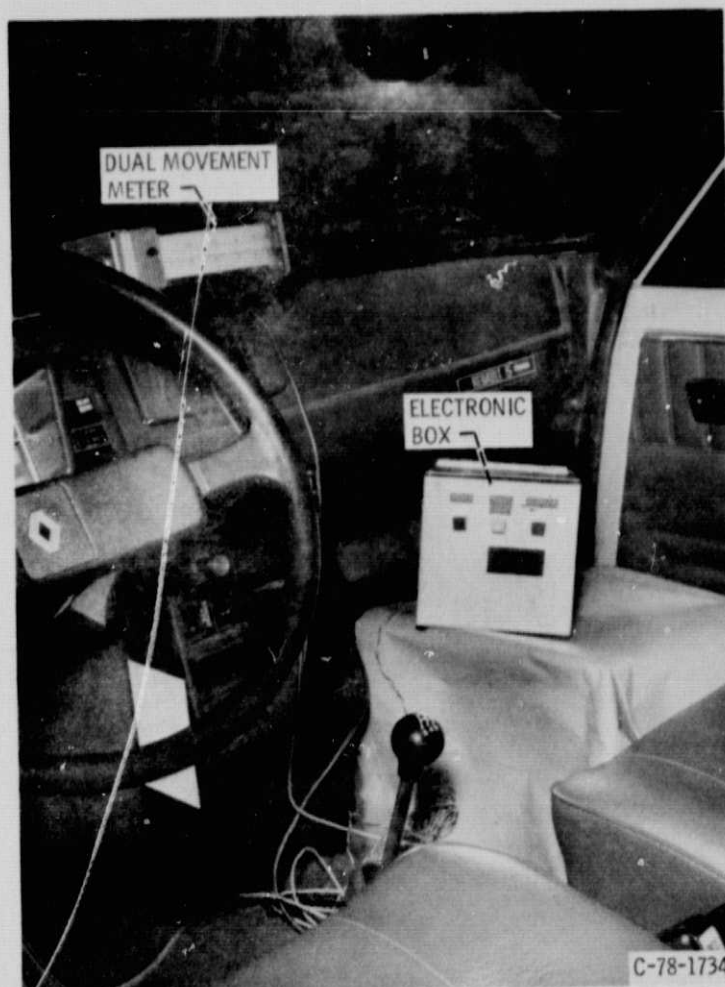


Figure 3. - Location of cycle timer in test vehicle.

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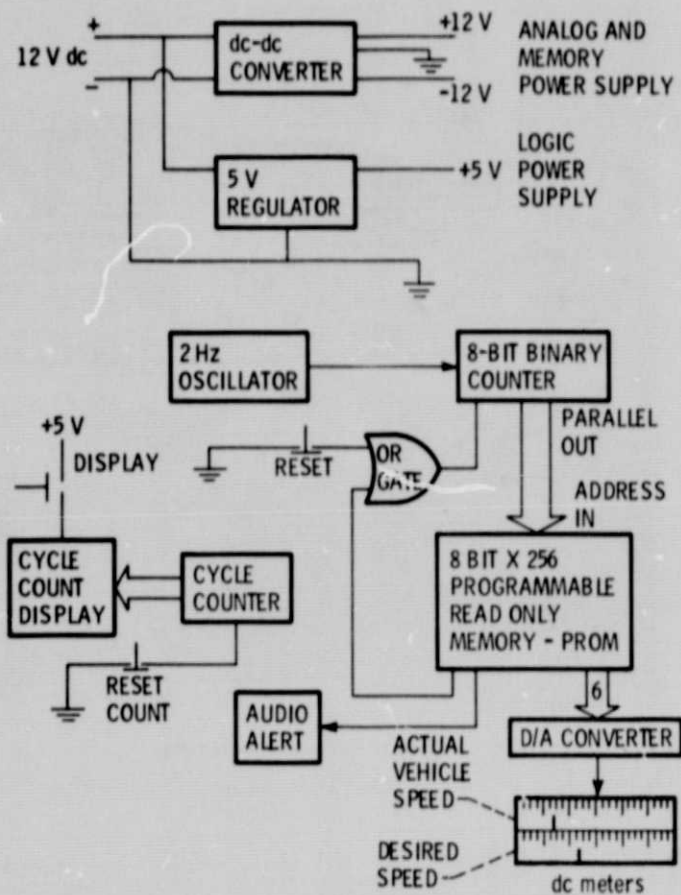


Figure 4. - Block diagram of cycle timer.

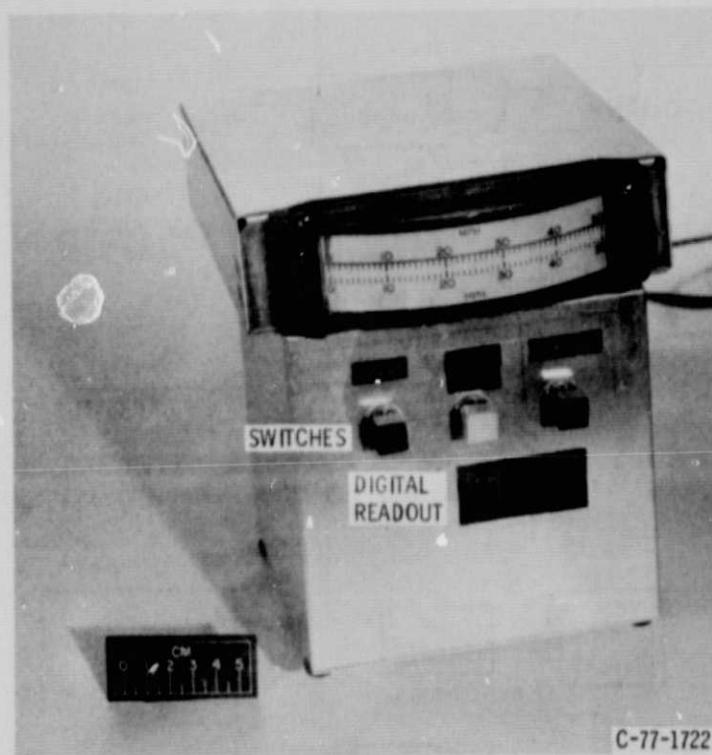


Figure 5. - Completed cycle timer.

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